

if the table is used appropriately. For instance, going horizontally in the table from Column 2 to Column 3 is equivalent to adding $\frac{1}{2}$ in. of fibrous insulation to the construction; similarly, going from Column 2 to Column 4 adds $1\frac{1}{2}$ in. of fibrous insulation to the construction. In the same way, going horizontally from Column 8 to Column 11 is equivalent to adding to a construction the insulating value of one additional highly reflective ($E = 0.05$) air space, and going from Column 6 to Column 12 in effect adds two non-reflective ($E = 0.82$) air spaces to the construction, etc.

CORRECTION FOR FRAMING

Correction for parallel heat flow through framing and insulated areas may be made by use of Fig. 5. Correction for the effect of framing should

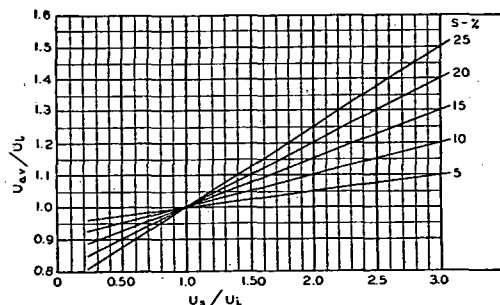


FIG. 5. CORRECTION FOR EFFECT OF FRAMING IN INSULATED BUILDING SECTIONS

U_{av} = average U value for building section.
 U_i = U value for area between framing members.
 U_s = U value for area backed by framing members.
 S = Percentage of area backed by framing members.

be applied after final U_i and U_s values have been obtained for a given construction. In many cases this correction may be omitted.

Example 1: Consider a frame wall with 2-in. blanket insulation which has a U_i value of 0.08. By calculation it is found that heat loss from the area backed by framing members (U_s) is 0.13. U_s/U_i is 1.63. From Fig. 5 if 15 per cent of wall area is backed by framing, the value $U_{av}/U_i = 1.1$. U_{av} is therefore $1.1 \times 0.08 = 0.088$.

Computed Heat Transmission Coefficients

Computed overall heat transmission coefficients of many common types of building construction are given in Tables 7 to 21. In the analysis of any wall construction for the purpose of calculating the overall coefficient of heat transmission U , it is first necessary to determine the paths of heat flow, that is, whether they are parallel or series, or a combination of both. This is in accordance with the basic laws of heat transfer which state that in parallel flow the conductances are additive, while in series flow the resistances are additive. Likewise, in order to determine the total resistance for the wall, the conductance must be known.

The importance of this analysis cannot be over-emphasized. This is especially true in wall constructions in which there are parallel paths of heat flow, and one path has a high heat transfer, while others have a low heat transfer. The method of making this calculation can best be shown by *Example 2* and Fig. 6. As this wall was tested by the hot box method

at the University of Minnesota, a direct comparison can be made between calculated and tested values.

Example 2: Calculate the coefficient of heat transmission U for a wall shown in Fig. 6. Wall construction consists of two 4-in. concrete walls separated by a $2\frac{1}{2}$ -in. space filled with insulation; $\frac{1}{4}$ -in. diameter metal tie rods are imbedded a distance of 1 in. in each 4-in. concrete wall, and spaced 9 in. vertically and 12 in. horizontally. Values of k are: insulation 0.30, concrete 12.00, tie rods 400.00.

Solution: In Fig. 6 the following paths of heat flow from plane A to plane F will be noted:

1. From A to B: One path through 3 in. of concrete.
2. From B to C: Two paths, (a) through 1 in. of tie rod, and (b) through 1 in. of concrete.

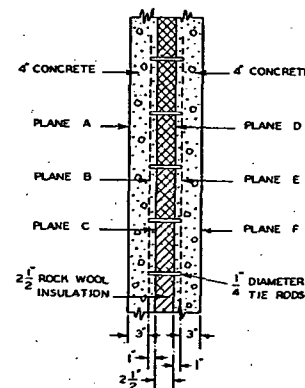


FIG. 6. SECTION OF CONCRETE WALL HAVING STEEL TIE RODS AND INSULATION

3. From C to D: Two paths, (a) through $2\frac{1}{2}$ in. of tie rod, and (b) through $2\frac{1}{2}$ in. of insulation.
4. From D to E: Two paths, (a) through 1 in. of tie rod, and (b) through 1 in. of concrete.
5. From E to F: One path through 3 in. of concrete.

It will be noted that items 2 and 4 are paths of similar flow, and could be treated as one. If equilibrium or steady state heat transfer is assumed, there will exist a temperature difference between the metal tie rod and the concrete, and also between the metal tie rod and the insulating material. The rate of heat transfer between these materials is dependent upon their conductivity values and the temperature difference. As the conductivity of the metal tie rods is considerably higher than that of the concrete or insulating material, it cannot be assumed that the same rate of heat transfer takes place for all parallel paths. Likewise, an appreciable error would be made by assuming that no heat transfer takes place between the metal tie rod and the surrounding materials. Although the pattern of the isotherms is unknown, the following method of calculation does partially take into account the heat flow between the metal tie rods and its bounding materials.

Parallel Flow. The conductances through the areas of parallel heat flow may be determined as follows:

1. The area of each $\frac{1}{4}$ -in. diameter tie rod is 0.00034 sq ft, and as the tie rods are spaced 9 in. vertically, and 12 in. horizontally, there will be $0.00034 \times \frac{48}{9} = 0.00045$ sq ft of tie rod to each square foot of wall area. Then from plane B to plane C, the conductance C_1 is

$$C_1 = \frac{0.00045}{1.0} \times \frac{400}{1.0} + \frac{0.99955}{1.0} \times \frac{12}{1.0} = 0.180 + 11.994 = 12.174$$